(19) Europäisches Patentamt
Eur pean Patent Office
Office européen des brevets

(11) EP 0 878 001 B1

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
10.10.2001 Bulletin 2001/41

(21) Application number: **96937957.7**

(22) Date of filing: **21.11.1996**

(51) Int Cl.[7]: **G10K 11/178**, F02M 35/00

(86) International application number:
PCT/CA96/00763

(87) International publication number:
WO 97/20307 (05.06.1997 Gazette 1997/24)

(54) **SYSTEM AND METHOD FOR REDUCING ENGINE NOISE**

VORRICHTUNG UND VERFAHREN ZUM VERMINDERUNG VOM MOTORLÄRM

SYSTEME ET PROCEDE PERMETTANT DE REDUIRE LE BRUIT D'UN MOTEUR

(84) Designated Contracting States:
DE FR GB IT

(30) Priority: **30.11.1995 US 565738**

(43) Date of publication of application:
18.11.1998 Bulletin 1998/47

(73) Proprietor: **SIEMENS CANADA LIMITED**
Chatham, Ontario N7M 5M7 (CA)

(72) Inventor: **EVERINGHAM, Gary**
Chatham, Ontario N7M 5J4 (CA)

(74) Representative: **Mackett, Margaret Dawn et al**
Siemens Group Services Limited,
Intellectual Property Department,
Siemens House,
Oldbury
Bracknell, Berkshire RG12 8FZ (GB)

(56) References cited:
GB-A- 1 456 018
US-A- 3 936 606
US-A- 4 665 549
US-A- 5 446 790

Note: Within nine months from the publication of the mention of the grant of the European patent, any person may give notice to the European Patent Office of opposition to the European patent granted. Notice of opposition shall be filed in a written reasoned statement. It shall not be deemed to have been filed until the opposition fee has been paid. (Art. 99(1) European Patent Convention).

EP 0 878 001 B1

Printed by Jouve, 75001 PARIS (FR)

Description

BACKGROUND OF THE INVENTION

[0001] The present invention concerns reducing internal combustion engine noise in automotive vehicles.

[0002] Reducing engine noise has long been an objective of automotive designers. One approach for reducing noise or certain sounds has involved electronically generating cancelling noises in response to particular sensed engine noises to reduce such noise levels. US-A-5 426 703 issued on June 20, 1995 for an 'Active Noise Eliminating System' and US-A-5 426 705 issued on June 20, 1995 for a 'Vehicle Internal Noise Reduction System' relates to such systems.

[0003] Some systems have used speakers to direct certain sounds into an enclosed space such as the passenger compartment of an automotive vehicle. However, the sounds are dispersed in the space such that the cancelling sounds are less effective at reducing certain noises or sounds than if the cancelling noises or sounds are concentrated to better neutralise the noise.

[0004] Another example of a noise reduction system is shown in US-A-3 936 606, where a noise wavefront propagated externally to a coherent propagation means is detected by a microphone external to the propagation means, and used to generate signals for controlling a speaker within the propagation means which provide for noise cancellation. The system is used in gas turbine engines where the speaker is a modulated gas flow speaker, coupled to one or more bleed ports which supply gas at one or more pressure offset from ambient pressure.

[0005] US-A-5 446 790 relates to a device for cancelling noise produced by an engine. The device is located in a chamber off the air intake duct of the engine and is controlled by a control unit which senses the intake sound of the engine and its rotational speed. Map data are produced in accordance with the phase difference between the sensed intake sound and the desired intake sound for a different rotational speeds. The phase difference data is used to drive at least one speaker to compensate for the sensed intake sound.

[0006] GB-A-1 456 018 relates to a method and apparatus for attenuating a sound wave propagating through a fluid contained in a duct. The apparatus comprises an array of sound sources which are located at differing positions in walls of the duct, each sound source generating a pair of sound waves designed to travel through the fluid in opposite directions. The array is controlled so that the sound waves generated thereby destructively interfere with the wave to be attenuated.

[0007] US-A-4 665 549 discloses acoustic attenuation apparatus in which a silencer is utilised for passively attenuating an acoustic wave travelling in a duct. At least one cancelling speaker is provided in the silencer for actively attenuating the acoustic wave. Each speaker is arranged in the duct such that the sound it produces travels in a direction transverse to or in the same sense as the direction of propagation of the acoustic wave.

[0008] The performance of such systems, however, depends on the generated cancelling noise.

[0009] It is therefore an object of the present invention to provide an active noise or sound reducing system that is more effective in reducing internal combustion engine noise.

SUMMARY OF THE INVENTION

[0010] The inventor has determined that certain internal combustion engine noises or sounds are propagated through the air induction system, and may include, for example, engine valve and combustion chamber noise, as well as the noise produced by inducing of air into the engine. Accordingly, the present invention, which is defined by the appended claims, comprises an air duct housing defining an annular space receiving the air passing into the air induction system. The center of the annular space is defined by the curved perimeter of a speaker enclosure, with a speaker coaxially mounted therein, facing upstream towards the flow direction of the incoming inducted air.

[0011] A sound transducer such as a microphone is mounted to the speaker so that it is adjacent to the annular space and approximately within the speaker face plane to detect engine noises or sounds in the induction system. The microphone detects the sounds and generates corresponding electrical signals that are phase shifted so as to be 180° out of phase from the engine noise signal and amplified. The amplified phase shifted signals power the speaker driver to create a cancelling noise or sound that interacts with the engine noise or sound emanating from the annular space. The cancelling sounds from the coaxially aligned speaker cone are absorbed so as to neutralize engine noise emanating from the annular space surrounding the speaker.

[0012] The rear of the speaker enclosure is preferably covered and insulated to limit cancelling sounds from propagating through the air induction system so as to lessen the effects of out-of-phase components relating to the generated cancelling sounds.

[0013] An adapter transition duct section may also be installed upstream of the speaker enclosure to allow connection to other air induction system components, such as the air cleaner, etc.

[0014] The speaker enclosure may also be tuned by adjusting its length so as to enhance the speaker's performance in cancelling dominant or selected frequencies of engine noise.

DESCRIPTION OF THE DRAWINGS

[0015]

Figure 1 shows the noise reducing system components according to the present invention together

with a block diagram representation of the engine and air induction system.

Figure 2 is an end view of a frame component shown in section in Figure 1.

DETAILED DESCRIPTION

[0016] In the following detailed description, certain specific terminology is used for clarity purposes and for describing a particular embodiment of the system. However, the particular embodiment is not intended to be limiting and should not be so construed since other embodiments may take different forms that are within the scope of the claims.

[0017] As described above, the inventor has determined that noises and sounds propagate through air in the air induction system, which draws air into the engine.

[0018] As shown in Figure 1, an air duct housing 10 is configured as a curved wall, smoothly convergent main air duct housing section 12 having a small diameter end adapted to be connected to the intake manifold of an internal combustion engine 14. An auxiliary transition section 16 may also be included, which has a divergent shape having its large end attached to or otherwise associated with a large diameter end of the main air duct housing section 12 by tabs 19 axially projecting from an outer rim 21 of a generally circular (round or oval) frame 18 attached to or otherwise associated with both structures. The transition section 16 provides convenient connection to the upstream air induction system components 20, such as the air cleaner, etc.

[0019] A speaker enclosure or assembly 22 is supported within the large end of the main air duct housing section 12 by a series of tabs 23 projecting from an inner rim 24 of frame 18. The speaker enclosure 22 has a curved outer perimeter, generally shaped to follow the inner contour of the large end of the main air duct housing section 12 so as to define a surrounding, annular air flow space 26 between the interior of the section 12 and the exterior of the enclosure 22.

[0020] The duct section 12 and speaker enclosure 22 may take various appropriate forms, including circular and oval shapes.

[0021] The frame 18 shown in Figure 2 has four equally spaced radial bars 28 supporting the inner rim 24 so as to allow adequate air flow into the annular space 26 from the transition section 16.

[0022] The speaker enclosure 22 is hollow and open at its larger diameter end facing the transition section 16, whereat the annular space 26 terminates. A speaker 30 is mounted to the rim 24 with suitable fasteners (not shown) received in holes 25 in the rim 24. The small diameter end of the speaker enclosure 22 is isolated by a solid plate 38 to reduce sounds from the rear of the speaker cone 32 that propagate to the downstream side of the speaker enclosure 22. A mass of sound deadening material 40 is disposed forward of the plate 38 and to the rear of the speaker cone 32 to further reduce such sounds.

[0023] A microphone 42 or other sound transducer is mounted within the air induction flow path by attaching it to or otherwise associating it with the frame 18 so that it is located just upstream of the annular space 26, approximately in the plane of the front of the speaker cone 32.

[0024] The microphone 42 generates an electrical signal corresponding to engine noise emanating from the annular space 26. The electrical signal is amplified in an audio broad band amplifier 44, the amplified electrical signal is input to the driver coil of the speaker 30 to output sound from the speaker cone 32. This signal is phase shifted by 180° , such as by switching the input leads to the speaker or by electronic means (not shown), to produce an "anti noise" or cancelling sound. Since the speaker output sound is 180° out-of-phase with the engine noises or sounds, they are absorbed so as to at least partially cancel and reduce the engine noise level.

[0025] The coaxial positioning of the speaker 30 within the annular space 26 and the positioning of the microphone 42 in the approximate plane of the speaker cone 32 better reduces engine noises. Since the engine noise is confined within the annular region surrounding the speaker cone 32, the cancelling noises or sounds from the speaker are better absorbed to partially cancel engine noises or sounds so as to reduce them.

[0026] The axial length L of the speaker enclosure may be adjusted or tuned to enhance the speaker performance in selected frequency bands of the engine noises or sounds. This may be done by setting the axial length L according to the following formula:

$$L = (C/4fs) - 1.9r,$$

where C is the speed of sound in air at sea level (1120 ft. per second (341.38 m/sec)), fs is the dominant or selected frequency, and r is the radius of the speaker enclosure.

Claims

1. A system for reducing noise produced by an internal combustion engine (14) having an air induction system (20), the system comprising:-

   a main duct housing (10, 12, 16) connected between the air induction system (20) and the internal combustion engine (14) for receiving air flow passing through the air induction system (20) and directing it to the engine (14);

   a speaker assembly (22, 30, 32, 38, 40) comprising an enclosure (22) and a speaker (30, 32) having a speaker cone (32) coaxially aligned within the enclosure (22);

   a sound transducer assembly (42, 44) compris-

ing a sound transducer (42) positioned to generate electrical signals corresponding to engine noises or sounds and an audio amplifier (44) connected to receive and amplify said electrical signals, the audio amplifier (44) having an output connected to drive the speaker (30, 32) with amplified signals phase shifted by 180° to generate cancelling sound from the speaker (30, 32); and

a mounting frame (18) for mounting the speaker assembly (22, 30, 32, 38, 40) within the main duct housing (10, 12, 16) so as to provide an annular flow space (26) within the main duct housing (10, 12, 16) which surrounds a perimeter portion of the speaker assembly (22, 30, 32, 38, 40), the speaker assembly (22, 30, 32, 38, 40) being mounted coaxially within the annular flow space (26);

characterised in that the transducer (42) is associated with the mounting frame (18) to be located upstream of the annular flow space (26) approximately in the plane of the speaker cone (32) and offset from the front of the speaker cone (32).

2. A system according to claim 1, wherein the enclosure (22) is hollow and has a closed end (38) and the open end faces the air induction system (20), the speaker (30, 32) being mounted within the enclosure (22) facing out of the open end thereof to face air flow in the main duct housing (10, 12, 16).

3. A system according to claim 2, further including a sound absorbing material (40) located within the closed end (38) of the enclosure (22).

4. A system according to any one of claims 1 to 3, wherein the annular flow space (26) terminates at the open end of the enclosure (22).

5. A method of reducing noise generated by an internal combustion engine (14) having an air induction system (20) which has a main duct housing (10, 12, 16) which receives air flow into the engine (14), the method comprising the steps of:-

a) mounting a speaker assembly (22, 30, 32, 38, 40) within the main duct housing (10, 12, 16) so as to provide an annular flow space (26) within the main duct housing (10, 12, 16) which surrounds a perimeter portion of the speaker assembly (22, 30, 32, 38, 40), the speaker assembly (22, 30, 32, 38, 40) comprising an enclosure (22) and a speaker (30, 32) having a speaker cone (32) coaxially aligned within the enclosure (22), the speaker assembly (22, 30, 32, 38, 40) being mounted coaxially within the annular flow space (26) to receive all of the air flow passing through the main duct housing (10, 12, 16);

b) mounting a sound transducer assembly (42, 44) within the main duct housing (10, 12, 16) for generating electrical signals corresponding to engine noises or sounds, the sound transducer assembly (42, 44) comprising a sound transducer (42) and an audio amplifier (44);

c) amplifying the electrical signals; and

d) driving the speaker (30, 32) with the amplified signals which are phase shifted 180° so as to generate sound from the speaker (30, 32) cancelling engine noises or sounds;

characterised in that step b) comprises locating the transducer (42) upstream of the annular flow space (26) approximately in the plane of the speaker cone (32) and offset from the front of the speaker cone (32).

6. A method according to claim 5, further including the step of adjusting the axial length of the enclosure (22) to enhance speaker performance in a dominant frequency band of engine noise.

Patentansprüche

1. System zur Verminderung des von einem Verbrennungsmotor (14) mit einem Lufteinlaßsystem (20) erzeugten Geräuschs, mit:

einem zwischen dem Lufteinlaßsystem (20) und dem Verbrennungsmotor (14) angeschlossenen Hauptleitungsgehäuse (10, 12, 16) zum Aufnehmen des durch das Lufteinlaßsystem (20) durchtretenden Luftstroms und zum Zuleiten zum Motor (14),

einer Lautsprecheranordnung (22, 30, 32, 38, 40) mit einer Einschließung (22) und einem Lautsprecher (30, 32) mit einem koaxial zur Einschließung (22) ausgerichteten Lautsprechertrichter (32),

einer Schallwandleranordnung (42, 44) mit einem Schallwandler (42), der so positioniert ist, daß er den Motorgeräuschen oder dem Motorschall entsprechende elektrische Signale erzeugt, und einem Audioverstärker (44), der so angeschlossen ist, daß er die elektrischen Signale empfängt und verstärkt, wobei der Audioverstärker (44) einen Ausgang aufweist, der so angeschlossen ist, daß er den Lautsprecher (30, 32) mit verstärkten, um 180° phasenverschobenen Signalen antreibt, um durch den Lautsprecher (30, 32) auslöschenden Schall zu erzeugen, und

einem Montagegestell (18) zur Montage der Lautsprecheranordnung (22, 30, 32, 38, 40) in-

nerhalb des Hauptleitungsgehäuses (10, 12, 16), um einen ringförmigen Strömungsraum (26) innerhalb des Hauptleitungsgehäuses (10, 12, 16) bereitzustellen, der inen Teil der P ripherie der Lautsprecheranordnung (22, 30, 32, 38, 40) umgibt, wobei die Lautsprecheranordnung (22, 30, 32, 38, 40) koaxial innerhalb des ringförmigen Strömungsraums (26) angeordnet ist,

dadurch gekennzeichnet, daß der Wandler (42) mit dem Montagegestell (18) so verknüpft ist, daß er stromauf von dem ringförmigen Strömungsraum (26) annähernd in der Ebene des Lautsprechertrichters (32) und von der Vorderseite des Lautsprechertrichters (32) abgesetzt angeordnet ist.

2. System gemäß Anspruch 1, wobei die Einschließung (22) hohl ist und ein geschlossenes Ende (38) besitzt und das offene Ende zum Lufteinlaßsystem (20) hin liegt, wobei der Lautsprecher (30, 32) innerhalb der Einschließung (22) so montiert ist, daß er aus deren offenem Ende herausschaut, um dem Luftstrom in dem Hauptleitungsgehäuse (10, 12, 16) zugewendet zu sein.

3. System gemäß Anspruch 2, außerdem mit einem schallabsorbierenden Material (40), das innerhalb des geschlossenen Endes (38) der Einschließung (22) angeordnet ist.

4. System gemäß einem der Ansprüche 1 bis 3, wobei der ringförmige Strömungsraum (26) am offenen Ende der Einschließung (22) endet.

5. Verfahren zur Verminderung des Geräuschs, das von einem Verbrennungsmotor (14) erzeugt wird, der ein Lufteinlaßsystem (20) aufweist, das ein Hauptleitungsgehäuse (10, 12, 16) aufweist, das den Luftstrom in den Motor (14) aufnimmt, mit folgenden Verfahrensschritten:

a) Anbringen einer Lautsprecheranordnung (22, 30, 32, 38, 40) innerhalb des Hauptleitungsgehäuses (10, 12, 16), um einen ringförmigen Strömungsraum (26) innerhalb des Hauptleitungsgehäuses (10, 12, 16) bereitzustellen, das einen Teil der Peripherie der Lautsprecheranordnung (22, 30, 32, 38, 40) umgibt, wobei die Lautsprecheranordnung (22, 30, 32, 38, 40) eine Einschließung (22) und einen Lautsprecher (30, 32) mit einem koaxial zur Einschließung (22) ausgerichteten Lautsprechertrichter (32) aufweist, wobei die Lautsprecheranordnung (22, 30, 32, 38, 40) koaxial innerhalb des ringförmigen Strömungsraums (26) angeordnet ist, um den gesamten, durch das Hauptleitungsgehäuse (10, 12, 16) durchtretenden Luftstrom aufzunehmen,
b) Anbringen einer Schallwandleranordnung (42, 44) innerhalb des Hauptleitungsgehäuses (10, 12, 16) zum Erzeugen von den Motorgeräuschen oder dem Motorschall entsprechenden elektrischen Signalen, wobei die Schallwandleranordnung (42, 44) einen Schallwandler (42) und einen Audioverstärker (44) umfaßt,
c) Verstärken der elektrischen Signale, und
d) Antreiben der Lautsprecher (30, 32) mit den verstärkten Signalen, die um 180° phasenverschoben sind, um durch die Lautsprecher (30, 32) Schall zu erzeugen, der die Motorgeräusche oder den Motorschall auslöscht,

dadurch gekennzeichnet, daß der Schritt b) das Anordnen des Wandlers (42) stromauf von dem ringförmigen Strömungsraum (26) annähernd in der Ebene des Lautsprechertrichters (32) und abgesetzt von der Vorderseite des Lautsprechertrichters (32) umfaßt.

6. Verfahren gemäß Anspruch 5, außerdem mit dem Schritt des Anpassens der axialen Länge der Einschließung (22), um die Lautsprecherleistung in einem dominanten Frequenzband des Motorengeräuschs zu verbessern.

Revendications

1. Système pour réduire du bruit produit par un moteur (14) à combustion interne ayant un système (20) d'induction d'air, le système comportant:

un logement (10, 12, 16) de conduit principal connecté entre le système (20) d'induction d'air et le moteur (14) de combustion interne pour recevoir un écoulement d'air passant par le système (20) d'induction d'air et le diriger vers le moteur (14);
un assemblage (22, 30, 32, 38, 40) formant haut-parleur comportant une enveloppe (22) et un haut-parleur (30, 32) ayant un cône (32) de haut-parleur aligné coaxialement à l'intérieur de l'enveloppe (22);
un assemblage (42, 44) formant transducteur sonore comportant un transducteur (42) sonore positionné pour produire des signaux électriques correspondant à des bruits ou sons de moteur et un amplificateur (44) audio connecté de manière à recevoir et amplifier les signaux électriques, l'amplificateur (44) audio ayant une sortie connectée de manière à attaquer le haut-parleur (30, 32) avec des signaux amplifiés décalés en phase de 180° pour produire des sons d'annulation en provenance du haut-parleur (30, 32) ; et

un cadre (18) de montage destiné au montage de l'assemblage (22, 30, 32, 38, 40) formant haut-parleur à l'intérieur du logement (10, 12, 16) de conduit principal de manière à obtenir un espace (26) d'écoulement annulaire à l'intérieur du logement (10, 12, 16) de conduit principal qui entoure une partie périphérique de l'assemblage (22, 30, 32, 38, 40) formant haut-parleur, l'assemblage (22, 30, 32, 38, 40) formant haut-parleur étant monté coaxialement à l'intérieur de l'espace (26) d'écoulement annulaire ;

caractérisé en ce que le transducteur (42) est associé au cadre (18) de montage pour être situé en amont de l'espace (26) d'écoulement annulaire approximativement dans le plan du cône (32) de haut-parleur et décalé par rapport à l'avant du cône (32) de haut-parleur.

2. Système suivant la revendication 1, dans lequel l'enveloppe (22) est creuse et a une extrémité (38) fermée et l'extrémité ouverte fait face au système (20) d'induction d'air, le haut-parleur (30, 32) étant monté à l'intérieur de l'enveloppe (22) faisant face vers l'extérieur de son extrémité ouverte pour faire face à l'écoulement d'air dans le logement (10, 12, 16) de conduit principal.

3. Système suivant la revendication 2, comportant en outre un matériau (40) d'absorption de son situé à l'intérieur de l'extrémité (38) fermée de l'enveloppe (22).

4. Système suivant l'une quelconque des revendications 1 à 3, dans lequel l'espace (26) d'écoulement annulaire se termine à l'extrémité ouverte de l'enveloppe (22).

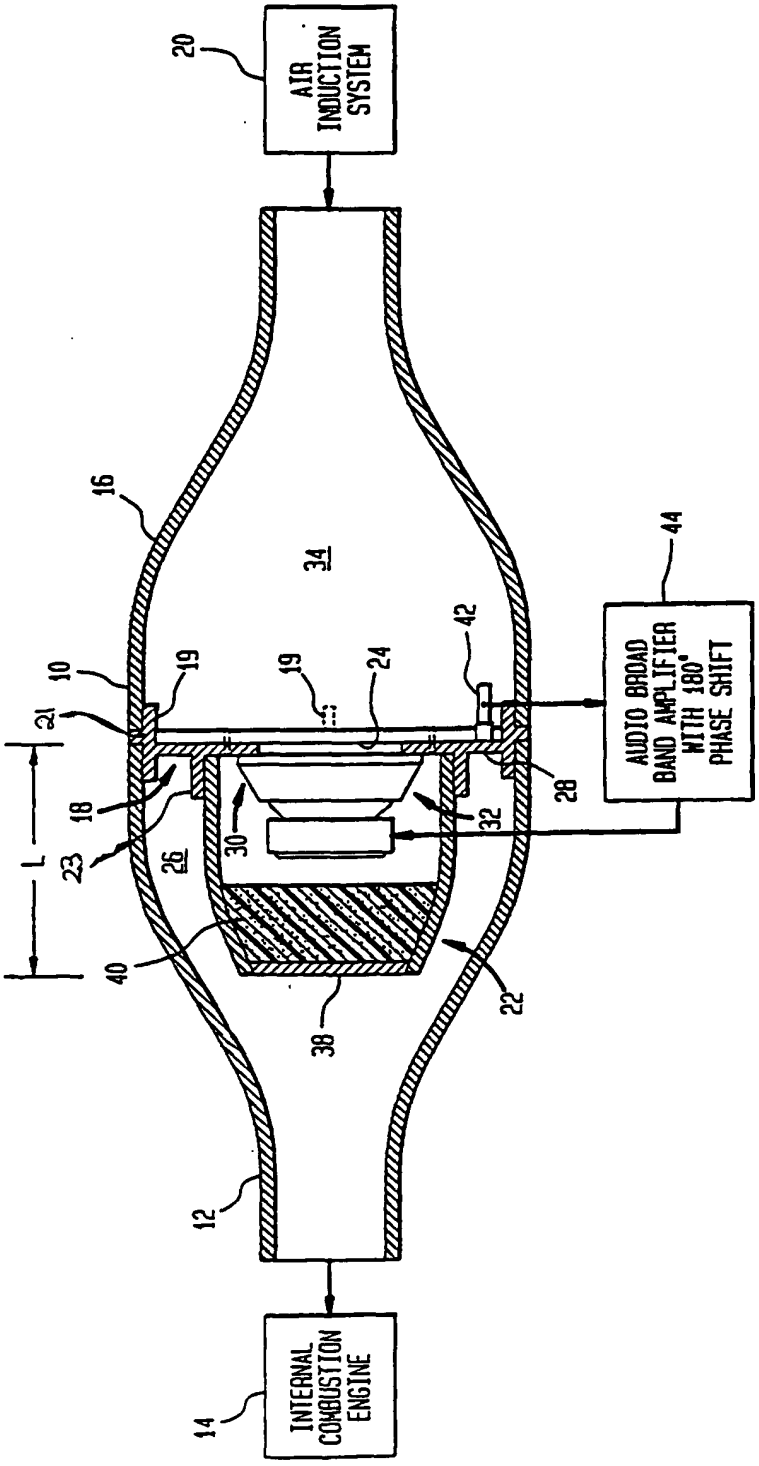
5. Procédé de réduction de bruit produit par un moteur (14) à combustion interne ayant un système (20) d'induction d'air qui a un logement (10, 12, 16) de conduit principal qui reçoit de l'écoulement d'air dans le moteur (14), le procédé comportant les étapes qui consistent à :

a) monter un assemblage (22, 30, 32, 38, 40) formant haut-parleur à l'intérieur du logement (10, 12, 16) de conduit principal de manière à obtenir un espace (26) d'écoulement annulaire à l'intérieur du logement (10, 12, 16) de conduit principal qui entoure une partie périphérique de l'assemblage (22, 30, 32, 38, 40) formant haut-parleur, l'assemblage (22, 30, 32, 38, 40) formant haut-parleur comportant une enveloppe (22) et un haut-parleur (30, 32) ayant un cône (32) de haut-parleur, aligné coaxiatement à l'intérieur de l'enveloppe (22), l'assemblage (22, 30, 32, 38, 40) formant haut-parleur étant monté coaxialement à l'intérieur de l'espace (26) d'écoulement annulaire pour recevoir tout l'écoulement d'air passant par le logement (10, 12, 16) de conduit principal ;
b) monter un assemblage (42, 44) formant transducteur sonore à l'intérieur du logement (10, 12, 16) de conduit principal pour produire des signaux électriques correspondant à des bruits ou sons de moteur, l'assemblage (42, 44) formant transducteur sonore comportant un transducteur (42) sonore et un amplificateur (44) audio ;
c) amplifier les signaux électriques ; et
d) attaquer le haut-parleur (30, 32) avec les signaux amplifiés qui sont décalés de 180° en phase de manière à produire des sons en provenance du haut-parleur (30, 32) annulant des bruits ou sons de moteur ;

caractérisé en ce que l'étape b) comprend l'étape qui consiste à placer le transducteur (42) en amont de l'espace (26) d'écoulement annulaire approximativement dans le plan du cône (32) de haut-parleur et décalé par rapport à l'avant du cône (32) de haut-parleur.

6. Procédé suivant la revendication 5, comportant en outre l'étape qui consiste à ajuster la longueur axiale de l'enveloppe (22) pour améliorer le rendement de haut-parleur dans une bande de fréquence dominante du bruit de moteur.

FIG. 1


AIR INDUCTION SYSTEM
20
16
34
44
AUDIO BROAD BAND AMPLIFIER WITH 180° PHASE SHIFT
42
10
19
19
24
21
28
18
32
30
23
26
L
40
22
38
12
INTERNAL COMBUSTION ENGINE
14

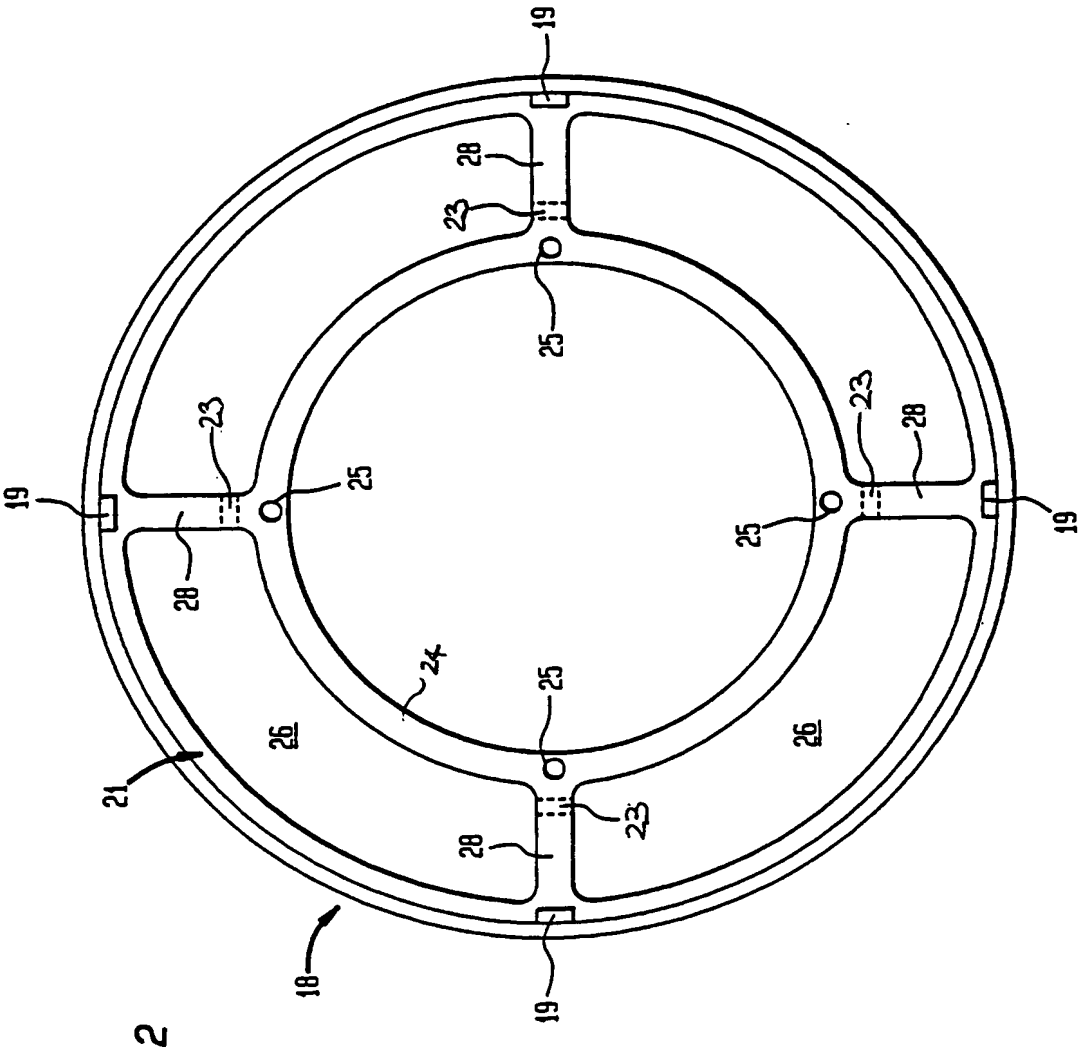


FIG. 2